NOTE ON MINERAL CONTENTS OF DARK HARD AND YELLOW HARD KERNELS SEPARATED FROM RED WINTER WHEAT[1]

Cereal Chem. 54(1): 183-186

E. DIKEMAN[2] and Y. POMERANZ[3], U.S. Grain Marketing Research Center, Agricultural Research Service, U.S. Department of Agriculture, Manhattan, KS 66502

Studies on functional properties (in milling and baking) of dark, hard, and vitreous (DHV) and yellow hard winter wheats were reported recently by Pomeranz *et al.* (1). Several explanations of the biochemical basis of wheat hardness and vitreousness associated with it have been suggested. Simmonds *et al.* (2) studied proteins and the composition of the starch-protein interface in wheats that differed in hardness. They related kernel hardness to the adhesive bond between starch and protein in the endosperm, rather than to the intrinsic hardness of the individual endosperm components. A fluorescent antibody study indicated that hard wheats contain a layer of water-soluble protein around their starch granules and that this layer is absent in soft wheats (3). Hoseney and Seib (4) examined different wheats as well as flours in a scanning electron microscope, and suggested that wheat hardness was governed by the strength of the protein-starch bond proposed by Simmonds *et al.* (2) and Wrigley (3). Furthermore, Hoseney and Seib (4) also postulated that differences in appearance and texture

[1]Cooperative investigations between USDA, ARS, NCR, and the Kansas Agricultural Experiment Station, Kansas State University. Contribution No. 924-J, Kansas Agricultural Experiment Station, Manhattan, KS 66506.

Reference to a company or product does not imply approval or recommendation of the product by the USDA to the exclusion of others that may be suitable.

[2]Research Assistant, Department of Grain Science and Industry, Kansas State University, Manhattan.

[3]Research Chemist, U.S. Department of Agriculture, and Professor, Agronomy Department, Kansas State University, Manhattan.

of wheat kernels are related to differences in light diffraction by air spaces in the starchy endosperm.

According to Headden (5), N-fertilization of the wheat plant lowered occurrence of yellow hard wheat, whereas K-fertilization enhanced it. The present study was thus conducted to find out if there actually is a difference in mineral composition between DHV and yellow hard kernels.

MATERIALS AND METHODS

Wheat Samples

Two samples from each of two hard red winter wheat cultivars 'Centurk' and 'Buckskin,' grown at three locations in Kansas (Hays, Newton, and Minneola), were separated by hand into DHV and yellow hard kernels. The DHV samples comprised 12.8 to 78.5% of the kernels in the six wheat samples.

Analytical Methods

These separated wheat samples were ground on a Weber pulverizer to pass a screen with 0.040-in. round openings. Moisture, ash, protein, and phosphorus were determined as described in AACC Approved Methods (6). All analytical data are expressed on a dry matter basis (db).

Samples for atomic absorption spectroscopy (AAS)[4] analysis were digested

[4]AAS also denotes atomic absorption spectrophotometer.

TABLE I
Ash Content and Kjeldahl-N of Separated DHV and Yellow Hard Fractions of Centurk and Buckskin Winter Wheats Grown at Three Locations in Kansas

Location and Variety	Fraction	Ash %	Kjeldahl-N %
Minneola			
Centurk	DHV	1.92	2.46
	Yellow hard	1.81	2.00
Buckskin	DHV	1.79	2.37
	Yellow hard	1.69	1.90
Hays			
Centurk	DHV	1.88	2.44
	Yellow hard	1.79	2.08
Buckskin	DHV	1.81	2.39
	Yellow hard	1.72	2.00
Newton			
Centurk	DHV	1.91	2.92
	Yellow hard	1.79	2.49
Buckskin	DHV	1.86	2.74
	Yellow hard	1.72	2.31

in duplicate as described by Liu *et al.* (7), and diluted to 25 ml. Standards were purchased from Fisher Scientific Co. Blanks and standard solutions were aspirated after every 7 to 10 samples, and deionized distilled water was aspirated between each sample. A Perkin-Elmer Model 306 atomic absorption spectrophotometer was used, with instrumental parameters set as recommended by the manufacturer. An air-acetylene flame was used for all elemental analyses except for Ca, which required a nitrous oxide-acetylene flame. Original sample solutions were diluted 100 times with 1500 ppm Na for K and Mg determinations, and 5 times with 1500 ppm La for Ca determinations.

RESULTS AND DISCUSSION

The DHV kernels contained, on the average, 19.7% more protein and 6.3% more total ash than did the yellow hard kernels. Protein and ash content were consistently higher in the DHV kernels for any of the six pairs of samples (Table I).

Contents of the eight minerals (P, K, Mg, Ca, Zn, Fe, Mn, and Cu) were higher in DHV than in yellow hard kernels (Table II). The average per cent difference was P, 7.1; K, 8.0; Mg, 8.4; Ca, 12.1; Zn, 9.4; Fe, 11.8; Mn, 8.9; and Cu, 17.9. The level of Kjeldahl-N was substantially higher than the level of K for the pairs of the DHV and yellow hard kernels, so the average N/K ratio was 6.18 in the DHV and only 5.58 in the yellow hard kernels.

Some of the percentage differences in individual mineral components were of about the same magnitude as the differences observed in total ash; therefore, we calculated the individual mineral components as a percentage of the ash, and treated these results to a statistical analysis by calculating the variance of the differences for all six pairs. The results indicated that at the 99% confidence level, only the copper content of the ash was significantly higher for DHV than for yellow hard kernels. Apart from its catalytic role in tyrosinase and ascorbic acid oxidase, no definite relation has been recognized between copper and any other specific processes in plants (8).

According to Ozolina and Lapina (9), soil fertilization with Cu enhanced

TABLE II
Range and Mean Mineral Contents of DHV and Yellow Hard Fractions of Centurk and Buckskin Winter Wheats Grown at Three Locations in Kansas

Mineral Component	Concentration db	Dark Hard and Vitreous Kernels		Yellow Hard Kernels	
		Range	Mean	Range	Mean
P	%	0.390– 0.418	0.405	0.363– 0.401	0.378
K	%	0.383– 0.443	0.415	0.358– 0.398	0.384
Mg	%	0.127– 0.145	0.137	0.119– 0.135	0.126
Ca	ppm	391–465	425	351–420	379
Zn	ppm	21.0 –27.8	22.1	19.5 –25.1	20.2
Fe	ppm	24.1 –41.6	30.4	22.6 –35.5	27.2
Mn	ppm	36.3 –39.5	39.0	31.7 –40.0	35.8
Cu	ppm	0.31 – 0.42	0.33	0.26 – 0.31	0.28

growth of wheat or barley caryopses; treatment of seeds with Cu, prior to sowing, increased the number of grains produced per plant. Protein content of barley caryopses, however, was higher in plants grown in a low Cu-deficient medium than in plants grown on a medium containing adequate amounts of Cu (10).

Calcium content of the ash was higher (at the 95% confidence level) for DHV than for yellow hard kernels. Calcium, which governs stability of α-amylase, is associated with pectic compounds in the middle lamella in cell walls of plant materials, and is important in nitrate reduction in plant tissues. The higher N contents of DHV kernels compared to yellow hard kernels could reflect their need for more calcium.

After completing this study, we learned that Fortini *et al.* (11) had studied the mineral elements in vitreous and yellow hard kernels of *Triticum durum*. They found that vitreous kernels contained more protein and organic S than did yellow hard kernels, but found no differences in ash, P, K, Zn, and Fe.

On the basis of grain analyses alone, the nature of a definitive relation between protein and mineral contents cannot be determined. Establishment of such a relationship would require extensive soil and plant tissue analyses as well as determination of the site of action and the role of mineral elements in vital metabolic processes.

Acknowledgment

F. S. Lai made the statistical analysis.

Literature Cited

1. POMERANZ, Y., SHOGREN, M. D., BOLTE, L. C., and FINNEY, K. F. Functional properties of dark hard and yellow hard red winter wheat. Baker's Dig. 50(1): 35 (1976).
2. SIMMONDS, D. H., BARLOW, K. K., and WRIGLEY, C. W. The biochemical basis of grain-hardness in wheat. Cereal Chem. 50: 553 (1973).
3. WRIGLEY, C. W. The biochemistry of the wheat protein complex and its genetic control. Cereal Sci. Today 17: 370 (1972).
4. HOSENEY, R. C., and SEIB, P. A. Structural differences in hard and soft wheat. Baker's Dig. 48(6): 26 (1973).
5. HEADDEN, W. P. Yellowberry in wheat—its cause and prevention. Colo. State Univ. Agr. Exp. Sta. Agr. Bull. 205 (1915).
6. AMERICAN ASSOCIATION OF CEREAL CHEMISTS. Approved methods of the AACC. Method 44-15A, approved April 1967; method 08-01, approved April 1961; method 46-11, approved April 1961; and method 40-56, approved April 1961. The Association: St. Paul, Minn.
7. LIU, D. J., ROBBINS, G. S., and POMERANZ, Y. Composition and utilization of milled barley products. IV. Mineral components. Cereal Chem. 51: 309 (1974).
8. MEYER, B. S., ANDERSON, D. B., and BOHNING, R. H. Introduction to plant physiology, p. 313. Van Nostrand Co., Inc.: New York (1960).
9. OZOLINA, G., and LAPINA, L. Physiological action of copper during the enrichment of seeds with this element. In: Mikrelem.-Regul. Zhiznedeyatel. Prod. Rast., ed. by J. Peive, p. 65. "Zinatne": Riga, Latv. SSR (1971). [Chem. Abstr. 75: 128876f.]
10. OZOLINA, G., and LAPINA, L. Formation of barley caryopses and their protein composition during a copper deficiency. In: Mikrelem.- Regul. Zhiznedeyatel. Prod. Rast. ed. by J. Peive, p. 37. "Zinatne": Riga, Latv. SSR (1971). [Chem. Abstr. 75: 128877g.]
11. FORTINI, S., SGRULLETTA, G., GALTERIO, and M. G. D'EGIDIO. Elementi minerali nelle cariossidi vitree e bianconate di Triticum Durum. Ann. Ist. Sper. Cerealicoltura 5: 177 (1974).

[Received May 19, 1976. Accepted August 3, 1976]